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A BIOLOGICAL EVALUATION OF PINE MORTALITY ON THE SAN JACINTO RANGER DISTRICT, SAN BERNARDINO NATIONAL FOREST

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ABSTRACT

Pine mortality increased on the southern half of the San Jacinto Ranger District during the fall of 1981. Fomes annosus, western dwarf mistletoe, pine engraver beetles and the California flatheaded borer were present in all mortality areas examined. Below-normal precipitation from mid-1980 through 1981 appears to be the underlying cause of the mortality. Mortality will return to a lower level within a few months after precipitation returns to normal. Some currently "green" trees will continue to die over the next few years because they have been too severely stressed by a combination of diseases, drought and insects to recover.

INTRODUCTION

Pine mortality increased suddenly on approximately 4,000 acres on the southern half of the San Jacinto Ranger District during the fall of 1981. District Resource Officer Jerry Creason requested an evaluation of the situation. Dave Schultz and John Kliejunas from the Forest Pest Management Staff and Dan Gosnell from the District examined several of the effected areas on December 15 and 16, 1981.

OBSERVATIONS AND DISCUSSION

Four large areas of concentrated mortality were examined in detail to determine the pests and site conditions which contributed to mortality. Other, smaller mortality areas were observed briefly; the conditions encountered were similar to those found in the larger areas.

The floor of Garner Valley at Quinn Flats meadow usually has some water flowing. This year the meadow was quite dry. The edges of the meadow are ringed with Jeffrey pines growing on benches of decomposed granite several feet higher than the valley floor. The pines tend to occur in clumps which have rather high stocking levels for the site. The major ground cover between the clumps of pine is sagebrush. Numerous pine stumps are present in the area and a high proportion of them are infected with the root disease fungus Fomes annosus. Heavy infections of western dwarf mistletoe (Arceuthobium campylopodum) add an additional stress to many of the trees. The combination of locally dense stocking, annosus root disease, dwarf mistletoe and reduced amounts of water available allowed successful attacks by pine engravers (Ips spp.) and the California flatheaded borer (Melanophila californica) on numerous trees.

The stands examined around Lake Hemet were comprised entirely of pine. There was no ground cover in the Lake Hemet Campground and Picnic Area and there appeared to be some soil compaction. The south-facing slope near the Picnic Area was sparsely timbered, with an abundant ground cover of grass and brush. Many of the trees were moderately to severly infected with western dwarf mistletoe. One of the areas examined had stumps infected with F. annosus. The level of Lake Hemet was considerably lower than normal. It is unknown whether the reduced lake level was entirely due to the low precipitation over the past year or to recent repairs on the dam, but in either case, water conditions for trees near the lake have been drastically altered. The chronic disease and poor to moderate site quality, combined with lower available water, allowed successful attacks on many trees by engraver beetles and by the California flatheaded borer. One tree was heavily infested with the red turpentine beetle (Dendroctonus valens). Under forest conditions, the red turpentine beetle is found successfully attacking only trees which have been previously attacked by other insects or trees under stress. Attacks on healthy vigorous trees are usually unsuccessful.

The sites examined near the top of Baldy Mountain varied from meadow-like, to sparse stands with grass, to fairly dense stands with rock outcrops. The tree cover was almost entirely Coulter pine and live oak. Dwarf mistletoe infections in the Coulter pine were heavy and widespread. There were numerous old stumps in the area and F. annosus conks were relatively common in the stumps that were checked. Coulter pine mortality in the area included some older dead trees, late summer fades, and a few trees which were just detectably off color. California flatheaded borers and pine engraver beetles were common in the dead trees. Many of the recently dead trees were at the margins of annosus root disease centers.

Several pockets of mortality were examined in the vicinity of Alvin Meadow. Rock outcrops were relatively common, giving the impression that the soil was not terribly deep. Tree cover was comprised of Coulter pine, live oak and some incense-cedar. Some of the aggregations, particularly where live oak was a component, seemed rather heavily stocked for the site. The Coulter pines were heavily infected with western dwarf mistletoe and the parasite was apparently affecting tree growth: one of the dead, mistletoe infected, pole size Coulter pine examined was growing at a rate of 25-30 rings per inch. Fomes annosus was also present in the area. There was some older incense-cedar and Coulter pine mortality as well as current pine

mortality in the area. The currently faded trees had been predisposed to attacks by the California flatheaded borer and pine engravers by the combination of site, stand and climatic factors.

The immediate cause of the death of the Coulter and Jeffrey pines in all the areas examined was successful attacks by the California flatheaded borer and pine engraver beetles. Diseases such as dwarf mistletoe and annosus root disease, and stand conditions such as heavy stocking or competition from grass and brush, undoubtedly contributed to the current mortality. These disease and stand conditions also keep the "normal" levels of mortality in the area higher than they would be without them. The incident which is responsible for the current upsurge in pine mortality is the lower than normal amount of precipitation received from mid-1980 through 1981. The exact amount of precipitation received at each of the mortality centers examined is unknown, but the weather records from Idyllwild can be used as an index (see Appendix). The total amount of precipitation received during 1978, 1979 and 1980 was above the average for the last 30 years, and this is reflected in the generally low rates of mortality during those periods. Although the total amount of precipitation during 1980 was far above average, 70 percent of it came in January and February, and flooding in nearby valleys indicates that a fair proportion was lost as runoff. From June 1980 through August 1981, each month's total precipitation was below the 30-year average. The reduced amount of water available to the trees resulted in lower resin pressure and less ability to callus over the attacking insects.

The biologies of the major pest organisms named above are discussed in the Appendix.

MANAGEMENT ALTERNATIVES

1. Do Nothing. Tree mortality levels will remain high until precipitation returns to normal. Experience and records in southern California indicate that the level of tree mortality increases greatly during periods of low rainfall and high moisture stress. Trees under additional stress from root disease and dwarf mistletoe will die first.

Mortality will return to lower levels after precipitation returns to normal, but existing stand conditions will cause the "background" level of mortality to be higher than that in intensively managed stands. Mortality due to pine engravers will probably decrease within a few months after precipitation increases. The California flatheaded borer will continue to breed in the boles of trees top-killed by engraver beetles and in trees stressed or predisposed to attack by root diseases, overstocking and dwarf mistletoe. Pines which regain full vigor after moisture stress is alleviated should be able to overgrow and kill any small flatheaded larvae present in their cambial area.

2. Salvage dead trees. This option will remove dead trees to enhance the scenic value along roads, realize some economic value from the killed timber, and/or provide firewood.

Under this option mortality can be expected to continue, necessitating repeated salvage. Additionally, disturbance in the moisture-stressed stands might increase the susceptibility of trees to insect attack. Any green pine slash laid on the ground before mid-July would tend to increase or maintain the pine engraver populations. A further consideration is that the major method of disposing of the dead trees would be as fuelwood to local residents. It is possible that dead trees could contain pine engraver broods which could cause tree mortality after emerging in residential areas. Also, some of the top-killed trees still have green butts which have the potential to attract a considerable number of engraver beetles. If this material is stacked adjacent to a backyard pine, the beetles attracted to it may be numerous enough to overcome the nearby healthy pine.

3. Integrate pest management considerations with stand prescriptions. Stand treatments will not end the current episode of high mortality, but will aid in lowering the "background" rate of mortality and minimizing losses during future periods of moisture stress. The integration of pest management considerations with stand prescriptions should bring about and maintain a low level of tree mortality during years of average or above-average rainfall, and prevent widespread tree mortality during periods of drought. However, some tree mortality will continue, especially in existing root disease centers and in stands with trees that are high insect risk and/or heavily infected with dwarf mistletoe.

Specific components of an integrated pest management system that appear appropriate include the following:

a. Borax stump treatment. *Fomes annosus* was involved in a substantial proportion of the mortality we observed. Where present, it plays a key role in predisposing trees to successful insect attack. New infections can be prevented by applying borax to freshly cut stumps of live or recently killed trees. Treatment of all freshly cut conifer stumps with borax is required in and near recreation sites (FSM R-5 Supp. 2305 and 2331.5).

b. Thinning. Thinning is an effective stand treatment for the prevention of bark beetle-caused mortality. The beneficial effect of thinning is especially apparent during periods of stress, such as periods of below-normal precipitation. Thinning can also be an important tool for minimizing the effects of dwarf mistletoe. The pathogen becomes especially damaging in stands that stagnate. Spacing control allows the trees to grow proportionally faster in height than the parasite moves upward in the tree. If the thinning is done early when the stems are small, the likelihood of annosus infection of the stumps will be decreased.

Basal area thinning guidelines are not available for specific pests. However, it is reasonable to expect that a level of thinning that results in the maintenance of good radial growth, height growth and a full crown will make the trees resistant to insect attack and killing.

c. Sanitation. Thinning provides an opportunity to remove trees that are infected by pathogens or that are likely to be attacked and killed by insects. Sanitation is also a useful tool for preventing future mortality from dwarf mistletoe.

d. Mixed stands. No feasible means of eradicating *F. annosus* from an infection center are known, so centers of mortality can be expected to enlarge indefinitely as roots of susceptible trees become infected at the margins of the center.

The effects of the fungus can be minimized, however, through the use of resistant species. Most hardwoods are resistant to the disease, and naturally occurring species may be successfully grown in openings created by the disease.

The encouragement of mixed stands is also a good dwarf mistletoe management technique. Given the narrow host range of most of the dwarf mistletoe species, it is frequently possible to encourage non-host species when thinning or planting. The western dwarf mistletoe present in the Coulter and Jeffrey pines examined can also infect ponderosa and knobcone pine, but other conifers and hardwoods are immune.

e. Overstory removal. Dwarf mistletoe-infected overstory trees present a special threat to susceptible trees growing nearby. Dwarf mistletoe seeds are forcibly discharged and land in the crowns of understory trees. Infections in the upper crown are especially damaging to the tree. It may be beneficial in the long run to remove selected overstory trees in order to prolong the life of the future stand. This is best done on an individual-tree or small-group basis which fits well into Forest Plans to manage by group selection.

Integrated pest management refers to the integration of specific treatments for reducing and/or preventing pest damage with on-going silvicultural prescriptions. The available options may or may not be appropriate in given situations. The specific pest and forest management prescriptions are written by the forest manager in light of the needs of the stand, and the objective for the stand.

APPENDIX

I. BIOLOGY OF PEST ORGANISMS

PINE ENGRAVER BEETLE

Pine engravers (*Ips* spp.) will breed either in the tops of live pine trees or in fresh green slash. Attacks on live trees are usually limited to trees which are suppressed, or stressed by dwarf mistletoe, root disease, drought, fire, or the attack of other insects. If fresh slash is available in the spring, the pine engravers may build up in an area and cause locally heavy top killing by mid-summer. Attacks are made with the coming of warm weather in the spring. A new generation is produced in 6-8 weeks in the spring to 4-6 weeks in mid-summer (August). Thus, several overlapping generations per year may be produced. The winter may be passed in any of the life stages of larvae, pupae, or adults, depending upon species involved.

Outbreaks in standing, healthy trees are sporadic and of short duration, and are often associated with some temporary stress or shock afflicting the host species, such as severe competition or sudden opening of the stand. Tree killing frequently occurs where green pine slash, which serves as breeding habitat, is left untreated during spring and summer.

Fresh pine slash caused by thinning, dwarf mistletoe control work, construction or winter storm breakage can be modified in a number of ways to make it unsuitable for pine engraver breeding. One approach to minimizing damage is to schedule slash-generating activities mostly between mid-July and late December, when the slash has a high probability of drying out before the beetles can complete their development. Green pine slash created during the spring and early summer should be treated to prevent the buildup of pine engraver populations. Because pine engravers can complete their development in about a month under ideal conditions, treatment should be carried out soon after cutting to be effective. Some methods of slash treatment that might be acceptable in dispersed recreation areas would include lopping and scattering slash in sunny areas to speed its drying out, crushing or mashing slash with logging equipment to make it unsuitable for pine engraver breeding, or piling and burning the slash within a month of cutting. Broadcast burning the slash might work if it could be done while the slash is green without damaging the residual stand. Another method which might work is to pile slash in a sunny area and tightly cover the pile with clear plastic. If the temperature under the bark of slash in all parts of the pile reaches 120°F, all brood currently in the pile will be killed. Lower temperatures will not be effective and, where successful, this method will not prevent reinfestation of slash piles. The most acceptable methods of slash treatment in high-use recreation areas would probably be disposal by chipping or removal from the site.

CALIFORNIA FLATHEADED BORER

The California flatheaded borer (*Melanophila californica*) principally attacks Jeffrey and ponderosa pines, although it may be found in other pines. It is most severe in stands located on sites where environmental stress is common. Decadent or unhealthy trees are most frequently attacked, along with an occasional top of a thrifty, vigorous tree.

Eggs are laid in bark crevices of the host tree. Newly hatched larvae penetrate directly through the bark to the phloem. Here the larvae may feed from a few months to 4 years without any apparent effect on the host tree. Should host vigor and larval abundance not allow them to succeed, the larvae cut very short galleries before they are killed. These galleries do not seriously injure the tree and are overgrown by the cambium. Should conditions be, or become, unfavorable for the tree and favorable for the larvae, the larvae develop rapidly and destroy the cambium.

ANNOSUS ROOT DISEASE

Fomes annosus is a fungus that infects a wide range of woody plants, causing decay of the roots and butt and the death of sapwood and cambium. All conifer species in California are susceptible to the fungus. Hardwood species are rarely damaged or killed. Madrone (*Arbutus menziesii*) and a few brush species (*Arctostaphylos* spp. and *Artemisia tridentata*) are occasional hosts.

During periods favorable to the fungus, fruiting bodies (conks) form in decayed stumps, under the bark of dead trees, or in the duff at the root collar. The fungus becomes established in freshly cut stumps from airborne spores produced by the conks, and then grows into the root system. The fungus subsequently spreads to healthy roots of surrounding susceptible species *via* root contacts. Local spread of the disease outward from an infected stump typically results in the formation of a disease center, with stumps and older dead trees near the center and fading trees on the margin. The centers continue to enlarge until they reach barriers, such as openings in the stand or groups of nonsusceptible plants.

The fungus may remain alive for as long as 50 years as a saprophyte in infected roots and stumps. Young susceptible trees invading the site often become infected and die after their roots contact old infected root systems in the soil.

WESTERN DWARF MISTLETOE

Western dwarf mistletoe (*Arceuthobium campylopodum*) infects Jeffrey, ponderosa, knobcone, and Coulter pines. Other conifers or hardwoods are not infected by this particular species. Dwarf mistletoes are obligate parasites that are completely dependent on their host for

support, water, and most of their mineral and organic nutrients. They often cause the formation of "witches' brooms", dense masses of distorted branches, on the host that divert nuturients from the rest of the tree. Infection can cause growth reduction, abnormalities, mortality and predisposition to attack by other pests. In particular, infected trees appear to be more susceptible to attack by bark beetles and the California flatheaded borer than do uninfected trees. The dwarf mistletoe/bark beetle complex is responsible for 40 to 60% of the pine mortality in southern California during years of normal precipitation. Mortality is more frequent when other stress factors occur, such as drought, oxidant air pollution damage, or competition in overstocked stands.

Dwarf mistletoe spreads between trees and within crowns of trees by means of small seeds that are forcibly ejected into the air. Spread from overstory to understory is limited to the distance the seeds are shot, generally 20 to 60 feet, but as much as 100 feet if assisted by wind or on steep slopes. Horizontal spread in an even-aged pine stand averages one to two feet per year with a vertical spread rate up the crown at about four inches per year.

APPENDIX

II. PRECIPITATION AT IDYLLWILD

YEAR	MONTH												TOTAL
	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC	
1951	4.00	2.17	1.25	3.65	0.64	0.00	2.22	0.51	0.25	1.43	1.34	14.56	32.02
1952	6.91	1.18	8.89	3.67	0.00	0.07	1.36	0.02	2.20	0.00	4.76	3.99	33.05
1953	2.60	1.05	2.38	2.20	0.90	0.00	0.35	0.89	0.00	0.35	1.32	1.15	13.19
1954	8.36	3.21	9.09	0.17	0.20	0.12	1.31	0.19	0.61	0.00	1.49	2.23	26.80
1955	5.85	4.45	0.05	0.76	1.80	T	1.32	3.62	0.00	0.00	1.81	2.89	22.52
1956	7.94	1.22	0.00	2.47	0.57	0.00	0.35	0.00	0.00	0.09	0.00	1.13	13.77
1957	8.96	1.30	2.47	1.66	4.54	0.97	0.13	0.10	0.00	4.02	2.57	3.08	29.80
1958	3.25	6.17	11.80	6.93	0.26	0.00	0.56	0.00	1.98	0.35	0.45	0.01	31.76
1959	1.03	7.49	0.00	0.36	0.17	0.00	0.13	0.95	1.61	1.35	1.35	5.09	19.53
1960	3.20	5.66	1.05	2.08	0.29	0.00	0.08	0.20	1.14	0.74	1.46	0.47	16.37
1961	1.37	0.00	2.27	0.22	0.43	0.00	0.05	1.18	0.00	0.60	1.77	2.95	10.84
1962	3.20	8.04	2.73	0.00	1.75	0.21	0.00	0.00	0.88	0.88	0.11	0.71	18.51
1963	0.94	4.70	3.03	3.65	0.00	0.00	0.00	0.31	3.91	1.39	5.02	0.27	23.22
1964	4.31	1.01	5.10	3.70	1.35	T	0.69	1.63	1.18	0.37	2.97	4.20	26.51
1965	1.49	1.90	3.30	7.54	0.02	0.00	1.11	0.75	0.54	0.10	13.59	6.02	36.36
1966	1.60	2.67	1.04	0.30	0.02	0.00	0.29	0.08	0.57	0.82	1.51	18.05	26.95
1967	4.04	T	4.43	4.94	0.47	0.05	2.00	1.95	1.51	0.00	2.91	3.81	26.11
1968	1.65	0.78	2.67	2.97	1.02	T	2.47	0.11	0.00	0.36	0.95	3.13	16.11
1969	17.61	12.60	3.36	1.38	1.07	0.00	0.22	0.00	0.52	0.19	2.42	0.43	39.80
1970	2.28	1.37	7.42	1.02	0.00	0.00	0.69	3.20	0.05	0.14	4.13	6.45	26.75
1971	2.46	1.01	0.88	1.89	2.08	0.00	0.81	0.15	0.05	1.59	0.39	8.75	20.06
1972	0.05	1.22	T	0.64	0.42	2.14	0.08	1.23	0.11	0.74	3.64	4.57	14.84
1973	4.16	6.16	7.87	0.47	0.31	0.00	0.00	0.61	0.00	0.36	3.10	0.59	23.63
1974	8.39	0.31	3.53	2.10	0.09	0.00	1.01	0.43	T	3.06	0.15	2.12	21.19

	MONTH												
YEAR	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC	TOTAL
1975	0.50	2.66	7.16	3.32	0.75	0.00	0.14	0.00	1.58	1.18	2.50	0.50	19.94
1976	0.00	7.72	3.13	1.84	1.82	0.01	0.66	0.00	8.31	0.30	0.91	2.52	27.22
1977	3.50	1.13	2.57	0.31	4.77	0.25	0.01	3.22	0.00	0.18	0.44	6.25	22.63
1978	12.17	7.64	10.52	3.25	0.68	T	0.84	0.00	0.85	0.62	4.70	5.72	46.99
1979	7.00	5.48	8.73	0.00	0.34	T	2.26	1.69	0.02	2.37	0.18	1.55	29.62
1980	14.35	17.43	6.63	2.29	1.60	0.01	0.08	0.00	0.00	0.36	0.00	2.90	45.65
1981	3.19	3.22	3.37	1.22	0.60	0	T	T	1.03				
30 year aver-age	4.71	3.90	4.09	2.16	0.93	0.12	0.68	0.77	0.93	0.80	2.26	3.87	25.39